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Arctic fox (*Alopex lagopus*) from the North Sea

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ABSTRACT

The first record of arctic fox *Alopex lagopus* (LINNAEUS, 1758) from the Eurogeul area (North Sea) is reported based on a distal humerus fragment collected by private collectors from dredged sediments on 'De Zandmotor'. It was radiocarbon dated to 29,900 ± 550/- 490 BP (GrA-69520), which is younger than most Late Pleistocene fossils from this area. Besides adding a new species to the faunal list of the Eurogeul area, this specimen also demonstrates the value of beaches nourished with dredged sediments and highlights the importance of close cooperation between all parties interested in palaeontology: from collector to researcher. The discovery prompted re-examination of the other arctic fox specimen from the North Sea, a femur of which the identification is here confirmed and measurements are provided.

Keywords Eurogeul area, Pleistocene, private collectors, radiocarbon dating, Zandmotor

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INTRODUCTION

The southern part of the North Sea has a rich fossil record of (Late) Pleistocene vertebrates (Mol *et al.* 2008). Traditionally, specimens have been recovered mainly through bycatch of commercial fishing activities by beam trawlers (Mol 2016), but there have also been several palaeontological expeditions with such vessels (Mol & Post 2010). In the past years a change in the fishing methods employed has significantly reduced the volume of bycaught fossil remains, thus diminishing fossil discoveries directly from the North Sea (Mol 2016). However, large scale land reclamation projects utilizing fossiliferous sediments

dredged from the North Sea bed have started to yield significant amounts of fossils: the Rotterdam port extension Maasvlakte 2 may be the best example (Reumer *et al.* 2010, Mol 2016), but the experimental sand supplementation project 'De Zandmotor' near The Hague (Van der Valk *et al.* 2011) is also an important site for Pleistocene fossils.

De Zandmotor is an artificial peninsula that was deposited by trailing suction hopper dredgers in 2011 along the beach south of The Hague. It consists of some 21 million cubic meters of sediments, dredged from two sand source areas ca. 10 kilometres from the shoreline (Langeveld 2013). These sand source

areas are located ca. 10 kilometres NE of the Eurogeul which is well-known to yield many Late Pleistocene vertebrate fossils (e.g. Mol *et al.*, 2008) and are included in the so-called 'Eurogeul area'.

Since the completion of De Zandmotor and the opening of the beach to the public, private fossil collectors have been active there. Some of them have amassed collections numbering thousands of specimens of Late Pleistocene and early Holocene vertebrates. Most of the private collectors are readily available to provide access to their collections, share their fossil discoveries, lend specimens for study and sometimes they are even willing to donate them to public collections. An intense collaboration between the fossil collectors, non-professional researchers and professional palaeontologists exists, yielding gains for all involved. This has revealed and saved many important fossils in the past decades (Mol 2016). These fossils may otherwise have become lost to science because they were not recorded, or because they are destroyed by weathering.

Large and fragile remains, including long bones or skulls of woolly mammoth, are always damaged in the dredging process and therefore are never found as complete specimens on De Zandmotor. In contrast, remains of smaller mammals or small bones of larger mammals are often recovered relatively unscathed. In fact, many of such smaller remains have rarely or not at all been recovered by fishing activities in the past and thus the finds from supplemented beaches are valuable additions that provide new data on past ecosystems (Mol 2016, Langeveld *et al.* 2016, 2017). From De Zandmotor, we describe here the first record of the arctic fox *Alopex lagopus* (LINNAEUS, 1758) from the Eurogeul area and provide a ^{14}C date for it. This discovery prompted re-examination of the other arctic fox specimen so far recorded from the North Sea (Bruine Bank locality; Mol *et al.* 2008), of which the identification is now confirmed. Their measurements are provided.

MATERIAL AND METHODS

During a public fossil identification day in the museum Museum (The Hague) on April 16, 2016, fossil collectors Vic Vieveen and Mark Zondag (both from The Hague) donated several fossil mammal and bird remains to the collection of the Natural History Museum Rotterdam (NMR) (Langeveld 2016). These were studied and added to the collection. The present contribution deals with one of these specimens: a partial humerus, registered as NMR 999100013217. The other North Sea *Alopex lagopus* specimen, a left femur, is kept in the private collection of Mr. Kommer Tanis (Havenhoofd, the Netherlands) and has number 581. The specimens were identified through direct comparison with recent disarticulated skeletons of various species (Canidae, Felidae, Mustelidae) in the NMR collection. Measurements were taken with Vernier callipers (accuracy 0.1 mm) following Von den Driesch (1976): Bd humerus: greatest breadth of the distal end, GL femur: greatest length, SD femur: smallest breadth of the diaphysis.

For radiocarbon dating, the bone collagen was prepared as the datable fraction following Longin (1971). Following this chemical pretreatment, the sample was combusted to CO_2 by an elemental analyser. The CO_2 gas is cryogenically trapped,

and next reduced to graphite under H_2 gas (Aerts-Bijma *et al.* 2001). The Carbon isotope ratios ($^{14}\text{C}/^{12}\text{C}$ and $^{13}\text{C}/^{12}\text{C}$) in the graphite are measured by AMS (Accelerator Mass Spectrometry). The Groningen AMS is based on a 2.5 MV particle accelerator (Van der Plicht *et al.* 2000). The measured isotope numbers are converted to conventional radiocarbon dates in BP (Mook & Streurman 1983). The laboratory background for fossil bone samples is 45,000 BP (Van der Plicht & Palstra 2016).

RESULTS

The Zandmotor specimen (Fig. 1) consists of a distal part of a humerus sin., with a maximum length (prior to sampling for ^{14}C dating) of 58.2 mm. It is well preserved and does not show signs of reworking. It was identified as a small canid based on, among other, the supratrochlear foramen. The distal epiphysis is fully fused to the diaphysis, indicating an adult animal. Its morphology (but not size) agrees well with red fox *Vulpes vulpes* (LINNAEUS, 1758). The distal width (Bd) equals 16.9 mm. This value lies below the observed values for *Vulpes vulpes* (Table 1). The bone collagen had excellent quality parameters (DeNiro 1985). The radiocarbon date (laboratory code GrA-69520) yielded $29,900 \pm 550$ BP, which calibrates to 34,510-33,600 calBP using the calibration curve IntCal13 (Reimer *et al.* 2013). The time unit calBP is calendar years



Figure 1 Distal fragment of humerus sin. of *Alopex lagopus* (NMR 999100013217) from De Zandmotor (Eurogeul area). Scale bar equals 3 cm. Left anterior view, right posterior view. [Bram Langeveld]

Table 1 Maximum width of the humerus' distal epiphysis (Bd hum.), total length of the femur (GL fem.) and smallest width of the shaft of the femur (SD fem.) in mm of the fossils and recent *Alopex lagopus* and *Vulpes vulpes* in the collection of the Natural History Museum Rotterdam and from selected literature. (* a young individual where the proximal epiphysis of the humerus has not yet fully fused with the diaphysis.)

	Coll. number/Source	Sex	Bd hum.	GL fem.	SD fem.	GL/SD fem.
Fossil	NMR 999100013217		16.9			
	Tanis collection 581			110.3	7.5	14.7
<i>Alopex lagopus</i>	Baryshnikov 2006		14.8-18.4			
	NMR 999000003567	M	17.3	115.8	7.4	15.6
<i>Vulpes vulpes</i>	Germonpre & Sablin 2004	M/F	20.0-24.8	120.0-141.8		
	NMR 999000000145	F*	18.4	120.6	8.7	13.9
	NMR 9990000003111	M*				
	NMR 9990000000839	M	19.6	124.8	9.3	13.4
	NMR 9990000000826	M*	19.7			
	NMR 9990000003130	F	19.8	122.1	9.3	13.1
	NMR 9990000000825	F	20.0	128.9	9.0	14.3
	NMR 9990000001961	?	21.2	134.6	9.5	14.2
	NMR 9990000003132	M	21.5	137.2	10.5	13.1
	NMR 9990000000824	F	22.2	134.0	10.4	12.9
	NMR 9990000003122	M	22.6			
	NMR 9990000000823	M	23.2	140.8	9.7	14.5

relative to 1950 AD (calBP = 1950-AD). The quoted errors are 1-sigma.

The Tanis specimen (Fig. 2) consists of a slightly damaged adult left femur that was reconstructed from the original parts. Both the proximal and distal epiphyses are damaged, which hampers obtaining accurate measurements of these parts. Its GL however can be reliably measured: 110.3 mm. This value lies below the observed values for *Vulpes vulpes* (Table 1). The collector has stabilized the fragile specimen by immersing it in diluted glue, rendering it unreliable for radiocarbon dating.

DISCUSSION

In the Late Pleistocene of North West Europe two fox species occurred (sometimes sympatrically), the red fox *Vulpes vulpes* and the arctic fox *Alopex lagopus* (Sommer & Benecke 2005). The red fox grows larger than the arctic fox and most of the standard measurements on long bones can reliably separate both species, including the Bd of the humerus and GL of the femur (Monchot & Gendron 2010). The Bd of the De Zandmotor specimen (16.9 mm) is clearly lower than that of the measured *Vulpes vulpes* specimens (mean 20.8 mm, standard deviation 1.5 mm; Table 1) and data on *Vulpes vulpes* from the literature (Germonpre & Sablin 2004; Table 1). It compares well to the sizes of *Alopex lagopus* reported in the literature (Baryshnikov 2006, Monchot & Gendron 2010; Table 1). The same goes for the GL of the femur of the Tanis specimen (110.3 mm) compared to our *Vulpes vulpes* material (mean 126.9 mm, standard deviation 9.9 mm; Table 1) and literature (Germonpre & Sablin 2004; Table 1); it is very close to the size range of *Alopex lagopus* from the literature (Monchot & Gendron 2010). An additional character may be the slender build of the femur of *Alopex* compared to that of *Vulpes*, expressed as GL/SD in Table 1. Therefore, we identify both NMR 999100013217 and

the Tanis specimen 581 as *Alopex lagopus*.

Although arctic fox had a huge European range during the Weichselian, including vast areas of Siberia, parts of Scandinavia, entire Central and East Europe and Great Britain and France (Kahlke 1999), remains have rarely been reported from the Netherlands. Up to 1995 not a single specimen had been published (Ahrens 1995). Later Mol et al. (2008) reported the Tanis specimen from the Bruine Bank site (North Sea) and Verhagen & Mol (2009) mentioned three specimens from the inland sand dredging site of De Groote Wielen near 's-Hertogenbosch. One of them, a partial cranium, yielded a radiocarbon date of 21,890 + 100/- 90 BP (Verhagen & Mol 2009, Mol et al. 2010).

Radiocarbon dates for fossil terrestrial mammals from the Eurogeul area range from 37,580 + 810/- 740 BP to 48,400 + 5800/- 3300 BP for the typical mammoth fauna including woolly mammoth and woolly rhinoceros ($n = 9$), and some younger dates for hare (*Lepus* sp.; 31,140 + 200/- 190 BP), fly pupae from a mammoth skull fragment (28,740 + 190/- 180 BP) and beaver (24,670 ± 150 BP) (Mol et al. 2006, 2008, Mol & Van der Plicht 2012, Van der Plicht et al. 2012). Our radiocarbon date for arctic fox, 29,900 + 550/- 490 BP, falls in the second category of dates, which seems to be younger than the true mammoth fauna from the Eurogeul area. Strikingly, this is the same case with the dated De Groote Wielen arctic fox, although that specimen is even younger at 21,890 + 100/- 90 BP (Mol et al. 2010). More dated arctic fox remains as well as more radiocarbon dates of mammoth fauna species from the Eurogeul area are necessary to evaluate these data.

CONCLUSION

The damaged humerus recovered from De Zandmotor is the first record of *Alopex lagopus* from the Eurogeul area. Besides



Figure 2 Femur sin. of *Alopex lagopus* (Tanis collection 581) from Bruine Bank, North Sea. Scale bar equals 3 cm. Left posterior view, right anterior view. [Bram Langeveld]

adding a new species to the faunal list of the Eurogeul area, this specimen also demonstrates the value of beaches nourished with dredged sediments and highlights the importance of close cooperation between all parties interested in palaeontology: from collector to researcher. Together with the Tanis specimen recorded earlier, the Zandmotor specimen makes up the complete fossil record of *Alopex lagopus* from the southern part of the North Sea.

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